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EVALUATION OF SELECTED WRAPPING FILMS FOR FRESH MEAT PACKAGING

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PREFACE

The laboratory tests in this report were conducted by the University of Missouri under purchase order agreement. The work is closely related to a contract conducted by the University of Missouri for the Transportation and Facilities Research Division and the Market Quality Research Division, Agricultural Research Service, to study factors affecting shelf life of prepackaged fresh meats.

Special credit is given to the FMC Corporation, American Viscose Division, Philadelphia, Pa., and to the DuPont Company, Wilmington, Del., for their advice and counseling. Appreciation is also given to the Market Quality Research Division, ARS, and to various people in the wrapping film industry for their review of the manuscript and many helpful suggestions.

This study was conducted under the general direction of R. W. Hoecker, Transportation and Facilities Research Division, ARS. Statistical analysis of the data, including tables and charts, was done by the Biometrical Services Staff, ARS, under the specific direction of Daniel A. Niffeneger.

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Evaluation of Selected Wrapping Films For Fresh Meat Packaging

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SUMMARY

The length of the display period, the temperature and the amount of light in the display case affected the shelf life and salability of packaged beefsteaks more than the wrapping film used.

Meat displayed at 30 F. had more desirable color retention, less weight loss, and lower bacteria count than meat displayed at 38°. At 30°, slightly more of the weight loss was absorbed by the packaging materials. Packages stored in darkness were less subject to discoloration, bacteria growth, and weight loss than those in lighted display.

A consumer panel found some significant differences among the color desirability scores of beefsteaks wrapped in six different films; however, no definite pattern was established and no one wrapping film had an overall advantage over the others tested. Percent weight loss was the most significant factor affected by the various films. Steaks packaged in standard red meat cellophane lost significantly more weight than those packaged in other films; however, steaks packaged in standard red meat cellophane also had the lowest bacteria counts and the film and tray absorbed the least amount of the weight lost from the meat.

Display time was found to be very important since the consumer gets the desired quality piece of meat and the retailer has fewer counter pulls and rewrap problems when the meat is sold soon after it is placed on display. Indications are that proper handling and displaying of meat is more important than the packaging film being used.

INTRODUCTION

Wrapping materials influence the success of self-service meat departments in retail food stores. Trays or backing boards should provide a suitable base and act as a stiffener for many supple cuts. Film overwraps should provide visibility, sealability, and permeability to oxygen. In addition, the film should be suitable for machine use and durable enough to provide adequate protection. In the past, only a limited number of available films possessed these various qualities.

Recent innovations, such as the production of thinner wrapping materials, have provided many new types of films that have been sold for packaging fresh meats. However, very little was known about the effect of these films on the fresh meat packaged in them.

These studies of fresh meat packaging films were designed to answer questions about the effectiveness of several of the newer films for preserving meat quality, providing fresh visual appeal, and providing shelf life over extended periods of time.

[1] M. Doordan, agricultural economist (now on military duty), and D. L. Anderson, assistant branch chief, Transportation Research Branch, Transportation and Facilities Research Division, Agricultural Research Service; D. Naumann, professor, and W. Stringer, associate professor, Food Science and Nutrition Department, University of Missouri.

FRESH MEAT WRAPPING FILMS

For many years specially treated cellophane film was most frequently used to wrap red meats because of its strength, heat sealability, and oxygen permeability characteristic that permits red meat to "bloom"[2] in the proper manner.

Allen listed five types of films used for meat in 1950 and 14 types in 1964, with a number of variations of some of these new films.[3] In addition to totally new materials, modifications in some of the older films were developed. Thinner film stock of good character was made possible by improved technology. Lamination of two different kinds of film provided new uses for older products.

Allen also reported that flexible film packaging was estimated to be a $100 million industry in 1963 with 12 billion retail packages of processed and fresh meat wrapped. Estimates based on food store sales indicate that over 6½ billion packages of fresh meat are wrapped annually in retail establishments (table 1). Industry estimates of over 6 billion trays a year would be consistent with this because trayed products represent about 90 percent of fresh meat packages wrapped in retail food stores.

The majority of the retail food stores began converting from service meat departments to self-service meat departments after World War II. This was made practical because of the development of better refrigeration equipment and a treated cellophane film that helped to retard the discoloration of red meats.

Until recently, cellophane film was never seriously challenged by other types of film except for a period of shortage that occurred during the Korean war. Although some other substitute materials of rubber hydrochloride or polyethylene base were developed, they tended to be used on luncheon meats or on cuts with special problems such as large bone-in roasts. The most successful of the alternate products was a rubber based film; however, it was more difficult to handle than the flat sheets of cellophane.

TABLE 1.--Estimated meat sales and fresh meat packaged in food stores, United States, 1966

Type of store	Estimated meat sales	Fresh meat packaged
	Million dollars	1,000 units
Supermarkets[1]..	12,008	5,561,339
Superettes[2]....	2,372	751,758
Small stores[3]..	3,024	265,318
Butcher shops[4].	1,500	65,217
Total.....	18,904	6,643,632

[1] Supermarkets: Supermarket sales $50,455 million (Progressive Grocer) x 23.8 percent meat (Purdue University) x 95 percent of store sales self-service x 65 percent of meat packages wrapped in the store + 5 percent for rewraps and package discards ÷ average price per package wrapped in the store of $1.40.

[2] Superettes: Superette sales $9,055 million (Progressive Grocer) x 26.2 percent meat (Purdue University) x 65 percent of store sales self-service x 65 percent of meat packages wrapped in the store + 5 percent for rewraps and package discards ÷ average price per package wrapped in the store of $1.40.

[3] Small Stores: Small stores sales $11,240 million (Progressive Grocer) x 26.9 percent meat (Purdue University) x 18 percent of store sales self-service x 65 percent of meat packages wrapped in the store + 5 percent for rewraps and package discards ÷ average price per package wrapped in the store of $1.40.

[4] Butcher Shops: Butcher shop sales $1,500 million (1961 census) x 5 percent of meat wrapped ÷ average price per package wrapped in the store of $1.15.

Some suppliers of packaged luncheon meat items used special films when the items were processed at a central location and where large product runs of similar items were possible. Also, they were able to use special flexible packaging materials and so called "soft" films on specialized high-cost packaging machines. However, wrapping machines in supermarkets were designed for cellophane, either in rolls or sheets.

Many of the newer films have adequate oxygen permeability and because of the very thin material cost less than cellophane films. Also, these films have other characteristics that make them a satisfactory film for red meat, with good strength and a high resistance to punctures. For example, some of these new films can be stretched or heat shrunk and thus

[2] Technically, a color change due to the oxygenation of myoglobin to oxymyoglobin on meat surfaces.

[3] Talk by Nelson Allen, Manager, Packaging Market Development and Customer Service, Film Department, E. I. DuPont de Nemours & Co., American Meat Institute. Sept. 30, 1964.

the package is neater and more attractive. Many films do not have the moisture absorbency of cellophane. Moisture can create indentations or a "cockled" effect in absorbent films, which detract from package appearance.

Many retail store wrapping machines, especially semiautomatics, do not as yet handle these films. Roll film devices have been developed with hot wire cutoffs that simplify packaging with many of these films but these cutoffs do create a condition of film wastage in that more square inches of film are required to wrap a given package. Harwell and others reported that "The judgment and skill of operators in tearing film sheets from a roll varied. There was as much as 4 inches difference between the longest and shortest sheets, when 10 sheets each were torn off by 4 operators to fit a given package." [4]

COST OF WRAPPING

Direct labor and material costs are a primary concern in choosing a wrapping film. Material costs in most self-service meat departments run about 1.5 percent of sales and usually include a tray or board. For purposes of a film evaluation, trays or boards can be considered a constant cost.

In comparing costs, different methods of wrapping must be considered because not all methods are compatible with each type of film. By using generally quoted film prices and considering all soft films as one, a cost comparison can be developed between the older cellophane films and the new soft films.

Table 2 compares the labor, film, and tray cost for three methods of wrapping with cellophane and for two methods with soft films. Cellophane used with a semiautomatic wrapping machine is significantly lower in labor, film, and tray cost than is soft film used with a hand wrap roll feed device. However, because the investment in equipment is considerably more for the semiautomatic wrapping machines, for many smaller stores the very limited investment in a roll feed device makes it the better choice. Initial cost of equipment for a semiautomatic wrapping system using sheeted cellophane film was $5,600 compared with $175 for a hand-wrapping system using rolled soft film (one work station).[5] On fully automatic machines where there are no technical problems, only the film cost varies. Soft film has advantages in small stores and where fully automatic machines are used and helps explain why there is such a strong interest in the newer films.

TABLE 2.--Labor, film, and tray cost per package of wrapping fresh meat packages with cellophane and soft film

Items	Cost when wrapped in cellophane with--			Cost when wrapped in soft film with--	
	Hand iron	Semi-automatic wrapping machine	Fully automatic wrapping machine	Hand wrap roll-feed device	Fully automatic wrapping machine
	Cents	Cents	Cents	Cents	Cents
Labor[1].....	2.00	0.70	0.41	1.48	0.41
Film[2].....	0.77	0.77	0.79	0.52	0.61
Tray[3].....	1.00	1.00	1.00	1.00	1.00
Total cost.	3.77	2.47	2.20	3.00	2.02

[1] Average hourly wage for meat cutters set at $3.00. Time per package derived by Volz, M. D. See footnote 5, page 5.

[2] Film cost based on a given store's product mix to give a weighted average film cost per package. Sheeted cellophane film cost based on $0.0380 per 1,000 square inches; rolled cellophane film cost based on $0.0355 per 1,000 square inches (costs based on mix of three films, one of which is polyethylene coated); and rolled soft film cost based on $0.0274 per 1,000 square inches. Source: Volz, M. D. See footnote 5, page 5.

[3] Average list price of 4S, 2S, and 8S pulp trays less 2 percent, less 10 percent, and less 5 percent, respectively.

COUNTER PULLS OR REWRAPS

Frequently the number or percentage of counter pulls or rewraps in meat departments of retail food stores has been used as a means of determining the effectiveness of various packaging materials and methods. This method of analysis, however, leaves the opportunity for the results to be affected by a number of different variables other than the material being tested.

Evaluation of past U.S. Department of Agriculture studies of rewraps indicates some of these variables.

[4] Harwell, E. M., Anderson, D. L., Shaffer, P. F., Knowles, R. H. Packaging and Displaying Meat in Self-Service Markets. U.S. Dept. Agr. Market. Res. Rpt. 44, 86 pp. 1953.

[5] Volz, M. D. Systems and Equipment for Packaging and Price Marking Meat and Poultry in Retail Food Stores. U.S. Dept. Agr. Market. Res. Rpt. 773, 24 pp., illus. 1967.

TABLE 3.--Number of cuts of meat and percentage of meat pulled from case by class of meat products, in 3 selected stores, Washington; D.C., 1950 and 1960

Product category	1950[1]			1960[2]		
	Meat cuts	Fresh meat packages wrapped	Packages pulled from case	Meat cuts	Fresh meat packages wrapped	Packages pulled from case
	Number	Percent	Percent of category	Number	Percent	Percent of category
Beef	26	42.0	8.2	[3] 41	63.5	10.0
Veal	19	7.6	6.5	[4] 8	9.3	13.8
Pork[5]	21	27.7	8.6	12	11.1	6.7
Lamb	12	5. 7	10.1	[6] 14	3.5	11.8
Poultry[7]	13	17.0	8.4	13	12.6	16.0
Total or average	91	100.0	8.3	88	100.0	8.9

[1] Source: Dobbins, C. E., and Hoecker, R.W. See footnote 6, page 6.
[2] Source: Unpublished data cumulated in previous studies by the Wholesaling and Retailing Research Branch, Transportation and Facilities Research Division, ARS.
[3] Good and choice counted as different cuts.
[4] 1960 data breakdown not very specific and probably not valid.
[5] Ham excluded.
[6] One store listed only one lamb cut; therefore, lamb from this store was excluded from average and total meat cuts.
[7] Fresh poultry (not including frozen).

For instance, in 1950 a study of rewrap packages in three Washington, D.C., self-service meat departments indicated that 8.3 percent of the packages wrapped were pulled from the display case (table 3).[6] In 1960 a study indicated little change in the percentage of packages pulled from the case. The three stores studied had an average of 8.9 percent of packages wrapped pulled from the case (table 3). Two of the three stores were from the same companies that had participated in the 1950 study.

A large percentage of the counter pulls in 1950 were to change prices (table 4). In 1950 inside labels were used and a package had to be opened and rewrapped in order to change the price.[7] Without the price changes, the counter pulls in 1950 would have been only 5.7 percent of packages wrapped, although some price changes could also have represented packages requiring rewrapping for other reasons. This would seem to indicate a significant increase in number of counter pulls over the 10-year period in spite of any technical improvements.

[6] Dobbins, C. E., and Hoecker, R. W., Costs and Reasons for Rewrapping Prepackaged Meats, Poultry, and Cheese, U.S. Dept. Agr. Agr. Inf. Bul. 77, 34 pp. 1951.

[7] The inside label is a grease-resistant label placed against the meat inside the package as compared with adhesive backed labels that are attached with heat to the outside of the package.

TABLE 4.--Disposition of meat packages pulled from display counter in 3 selected stores, Washington, D.C., 1950 and 1960[1]

Reason for pull	1950	1960
	Percent	Percent
Rewrapped for price change	2.6	([2])
Converted and repacked[3]	1.0	4.1
Trimmed and repacked	1.1	1.1
Rewrapped[4]	3.3	2.9
Reduced for quick sale	--	.6
Discarded	.3	.2
Total	8.3	8.9

[1] Hams excluded.
[2] Outside labels did not require rewrapping for a price change.
[3] Cubed, ground, or reprocessed.
[4] Unattractive packaging, broken film.

Beef, veal, lamb, and poultry had a higher percent of pulls in 1960 than in 1950 (table 3). Pork, which was a much smaller percentage of sales in the 1960 studies, was also lower in percentage of counter pulls. However, these factors do not appear to be the cause of a higher percentage of counter pulls. The number of different types of cuts displayed did not vary greatly from one study to the other. The stores studied in 1960 had more beef cuts but fewer pork and veal. However, researchers involved felt that the amount of meat (number of packages of each type) kept in the display was significantly higher in 1960. Maintaining a large inventory on display would undoubtedly result in more discolored or damaged packages and more counter pulls. Thus, this difference in counter pulls over the 10-year

TABLE 5.--Percentage of fresh meat packages wrapped and pulled from case by class of meat product, both before and after improved sanitation, refrigeration, and management practices were adopted, Missouri, 1966-67

Product category	Total fresh meat packages wrapped in--				Packages pulled from case in--			
	Store A for 3 weeks		Store B for 2 weeks		Store A for 3 weeks		Store B for 2 weeks	
	Before	After	Before	After	Before	After	Before	After
	Percent	Percent	Percent	Percent	Percent of category	Percent of category	Percent of category	Percent of category
Beef	69.8	63.0	71.5	66.7	11.3	3.1	8.4	4.6
Pork	25.0	33.3	28.3	32.8	9.6	3.9	4.8	8.1
Lamb	2.0	1.7	0.2	0.5	41.1	19.0	11.1	4.3
Veal	3.2	2.0	None	None	35.8	22.6	None	None
Total or average	100.0	100.0	100.0	100.0	[1] 12.2	[1] 4.1	[1] 7.4	[1] 5.7

[1] Percent of total fresh meat packages wrapped.

period could be attributed to management decisions on display practices.

The University of Missouri, under a research contract with the Agricultural Research Service, studied two stores in Missouri in 1966-67. These two stores pulled an average of 9.3 percent of the meat packages placed in the display case. For 3 weeks in store (A) and 2 weeks in store (B) records were kept of the fresh meat packages wrapped and the packages pulled from the case. Then improved refrigeration and sanitation and management practices were adopted and records were again kept for the same time periods.

Results showed a general decline in the percentages of packages pulled from the case after the new practices were adopted (table 5). The only exception was in store B where the percentage of pork products pulled from the case increased after the new practices were adopted. The number of packages pulled for all the other products declined significantly.

Indications are that the amount of pull outs or rewraps is more closely related to degree of refrigeration, sanitation, and the various management practices than to the type of wrapping being used.

After results of these three studies were checked, it was apparent that because of variation in department management or company policies relative to full displays, a study of soft films used in the meat departments of retail food stores by an analysis of rewraps or counter pulls would not necessarily provide a true evaluation of the newer types of films. This observation has been substantiated by others. Harwell and others have stated, "The most important single factor governing the number of packages removed from the case was the ability of the market manager to determine the customer demand for different items."[8] Therefore, in order to study the effect of new films on retail meat cuts, it was felt that a test under more controlled conditions was advisable.

[8] See footnote 4, page 5.

RESEARCH PROCEDURE

A series of tests were set up under laboratory conditions to measure objectively and subjectively the effect on beefsteaks of packaging them in six different wrapping films. A pair of U.S. Choice beef short loins and a pair of U.S. Choice beef ribs were used for each of the eight cycles or replications of treatments in this study. A cycle totaled 62 steaks, each 3/4 inch thick. Each steak was cut on a bandsaw, scraped with a metal device, weighed, and placed on a paper backing board tray. The tray was made of white polished #2 cardboard with folded edges.

The steaks were then wrapped in one of the following films: (1) a standard red meat

cellophane, 100 gage; (2) a polyethylene-coated red meat cellophane, 90 gage; (3) a rubber hydrochloride, 75 gage; (4) a polyvinyl chloride, 75 gage; (5) a stretchable polyolefin (#1), 75 gage; and (6) a shrinkable polyolefin (#2), 60 gage.

After being wrapped, the steaks for each cycle were randomly subjected to the following variables: (1) days of storage, (2) temperature, and (3) light exposure.

The experiment was conducted under the following treatments:

(1) Light storage:--All possible combinations of 6 wrapping materials, 4 storage durations (3, 5, 7, and 10 days) and 2 temperatures (30° and 38° F.); steaks stored under 120 foot-candles of fluorescent lighting.

(2) Dark storage:--All possible combinations of 6 wrapping materials and 2 temperatures; examination of the steaks made only at the end of 10 days.

(3) Controls:--Two steaks were used as 0-day controls.

The two display cases were adjusted to maintain temperatures of 30° and 38° F. at the surface of a steak in the center of each display case. These cases had been adjusted to give even temperatures throughout the display area and were monitored for equal air temperatures throughout the test.

The steaks in each display were illuminated with 120 foot-candles of fluorescent lighting. One steak of such wrapping material was displayed in the dark by covering the surface of the steak with a backing board.

A subjective evaluation of the color and desirability of the steaks was made by a six member panel for each of the six films at 30° and 38° F. Three of the panel members were housewives and three of the panel members were trained panelists. No references such as color charts were available to the panelists for comparison.

Steaks were evaluated under the fluorescent lighting conditions used in the display cases. Each panelist observed every steak considered and evaluated them on the basis of color desirability and color description. A hedonic scale was used, as follows:

Color desirability		Color description	
Desirable	6	Bright	6
Moderately desirable	5	Slightly bright	5
Slightly desirable	4	Slightly dull	4
Slightly undesirable	3	Dull	3
Moderately undesirable	2	Greyish or brownish	2
Undesirable	1	Greenish	1

To obtain the initial weights, all steaks were weighed at the start of the cycle, both with and without the packaging materials. To obtain the final weights after display periods of 3, 5, 7, and 10 days' storage, one steak packaged with each film and at each temperature was weighed, both with and without the packaging materials. The weight loss percentage was determined by the following formula:

$$\text{Weight loss percentage} = \frac{\text{Initial weight} - \text{final weight}}{\text{initial weight}} \times 100$$

Because all the steaks were wrapped on the same type of backing board, it was assumed that the absorption rate would be the same for each board. Therefore, the remaining weight loss was attributed to evaporation through the various films or to differences in the absorption rate of the packaging materials.

A bacteria count was taken on one steak for each cycle at 0 days; then that steak was discarded. Similarily, bacteria counts were taken for each film studied after 3, 5, 7, and 10 days under 30° and 38° F.

Microbe counts of each steak were determined by using the "swab" method.[9] The bacteria sample was taken from $2\frac{1}{2}$ square inches of the steak surface by using a sterile swab and template. The swab was broken off into a screw-type test tube that contained a 0.1 percent peptone solution. The solution was then plated, using appropriate dilutions. The petri dishes were filled with standard methods agar and incubated at 70° F. and 3 days.

[9] American Public Health Association. Standard Methods for the Examination of Dairy Products. American Public Health Assoc., Inc., New York. 1960.

Information and results of other tests of a more technical nature were also completed on the same steaks. These include a pigmentation test as described by Dean and Ball,[10] a pH test, and a water holding capacity test as described by Grau and Hamm.[11] Results of the present tests, together with additional details on color, weight loss, and bacteria counts, are available in a supplement to this report upon request from the Transportation and Facilities Research Division, Agricultural Research Service, U.S. Department of Agriculture, Hyattsville, Md. 20782. When requesting information, please include your ZIP code.

COLOR DESIRABILITY AND COLOR DESCRIPTION

Results of the two color tests were found to be about the same; therefore, only the color desirability scores were chosen for analysis. Table 6 shows the average color desirability scores that were obtained from the panel members. Results of the color description tests can be found in table 11 of the appendix.

There were few significant differences between the color desirability scores of the beefsteaks wrapped in the six different films. No definite pattern was found to indicate specifically the desirability of one film over another. Any differences found were in the early period of display and were negligible by the 7th day.

At 30° F., color desirability scores for the steaks wrapped in standard red meat cellophane were significantly lower after 0, 3, and 5 days' storage than scores for steaks wrapped in the other five films. However, after 7 and 10 days' storage these differences were no longer evident. At 38°, scores for steaks wrapped in standard red meat cellophane were similar to those for steaks wrapped in other films.

[10] Dean, R. W., and Ball, C. O. Analysis of the Myoglobin Fractions on the Surface of Meat Cuts. Food Technol. 14: 271-286. 1960.

[11] Grau, R., and Hamm, R. A Simple Method for Determination of Water Binding in Muscle. Die Naturwissenschaften 40: 29-30. 1953.

TABLE 6.--Subjective color desirability scores of beefsteaks packaged in 6 wrapping films by display temperature and display periods, Missouri, 1966-67[1]

Temperature and Film No.	Film	Color desirability score of beefsteaks in display case[2]--						
		With light						Without light for 10 days
		For 0 days	For 3 days	For 5 days	For 7 days	For 10 days	Average	
30° F.:								
1	Standard red meat cellophane.....	5.39 c	4.81 b	4.05 b	3.74a	2.49a	4.10	3.90
2	Polyethylene-coated cellophane.....	5.46 bc	5.03ab	4.88a	4.41a	2.79a	4.51	4.18
3	Rubber base.....	5.57abc	5.10ab	4.54ab	4.13a	2.71a	4.41	3.76
4	Polyvinyl chloride.....	5.76a	5.00ab	4.88a	4.04a	2.69a	4.47	3.65
5	Polyolefin # 1 (stretch).....	5.70a	5.01ab	4.48ab	4.04a	2.38a	4.32	4.00
6	Polyolefin # 2 (shrink).....	5.63ab	5.35a	4.83a	3.83a	2.66a	4.46	3.65
	Average.....	5.59A	5.05B	4.61C	4.03D	2.62E	-	3.86
38° F.:								
1	Standard red meat cellophane.....	5.61a	4.65ab	3.83a	2.00a	1.16a	3.45	1.84
2	Polyethylene-coated cellophane.....	5.54a	5.09a	4.01a	1.74a	1.04a	3.48	1.20
3	Rubber base.....	5.63a	4.10 b	3.04a	1.41a	1.00a	3.04	1.05
4	Polyvinyl chloride.....	5.54a	4.64ab	3.44a	1.33a	1.11a	3.21	1.34
5	Polyolefin # 1 (stretch).....	5.73a	4.51ab	3.21a	1.71a	1.10a	3.25	1.06
6	Polyolefin # 2 (shrink).....	5.56a	4.95a	3.40a	1.83a	1.05a	3.36	1.16
	Average.....	5.60A	4.66B	3.49C	1.67D	1.08E	-	1.28

[1] Hedonic scale: 6 = desirable; 1 = undesirable.

[2] Film values having the same letter or letters within a column and averages having the same letter or letters within a row are not significantly different. Tests were administered at the 0.05 level of significance. No comparison was made between averages, which are identified by capital letters, and values within the table.

At both display temperatures, color desirability of the steaks decreased as the number of days of case display increased, regardless of the film being used. However, as the display period increased, the steaks in packages displayed at 30° F. retained their desirable color longer than those displayed at 38°.

A comparison of the effect of light on the color desirability of the steaks showed that most steaks held without light for 10 days scored higher than those displayed in a lighted display case for the same period of time. These results seemed to indicate that light has a detrimental effect on the color of beefsteaks, regardless of temperature. The only exception was the steaks in the polyolefin #1 (stretch) film at 38° F., which scored 1.10 with light and 1.06 without light. However, that one exception may have resulted from the higher display temperature, because the difference in scores with and without light was not as great at 38° as it was at 30°.

Figure 1 shows graphically the color desirability scores for the beefsteaks held at 30° F. by the type of wrapping film used. Figure 2 shows the same scores for steaks held at 38°. Comparison of the two figures shows that temperature at which the beefsteaks were displayed was very important for maintaining color desirability.

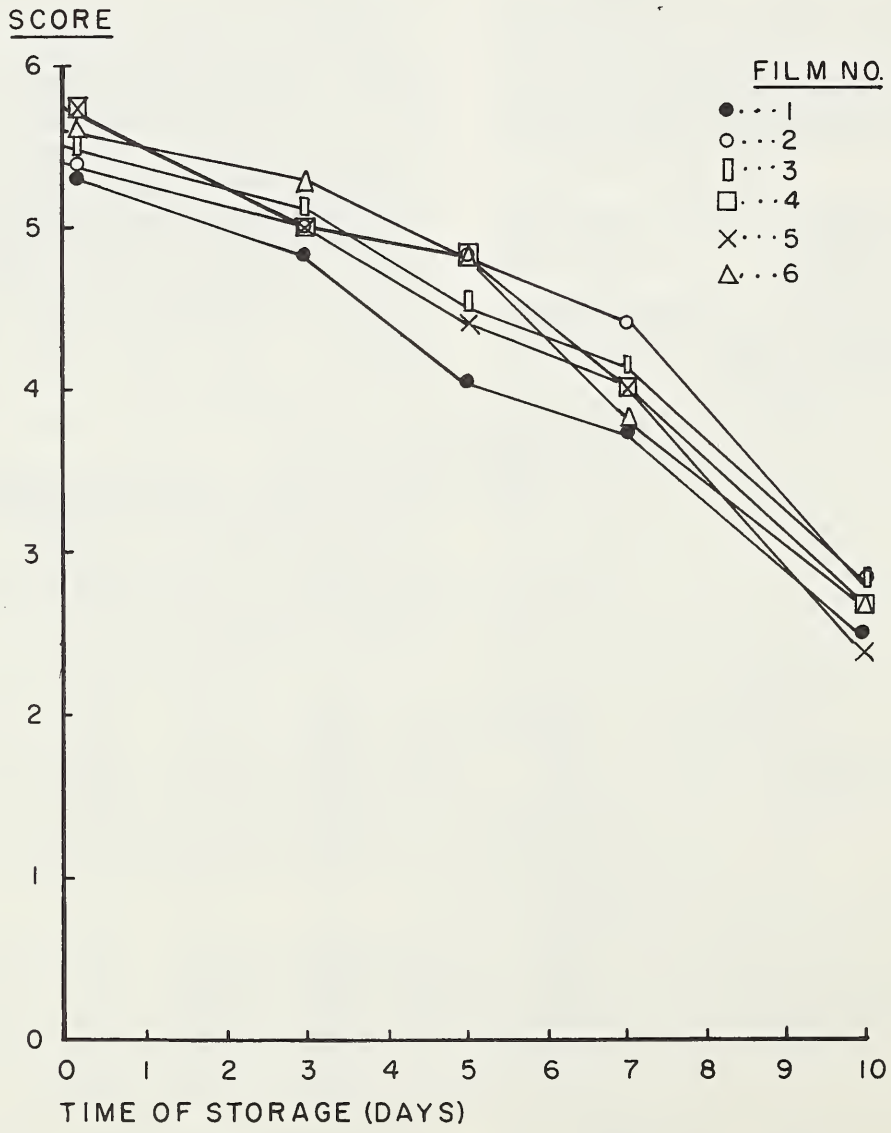

Figure 1.--Color desirability of beefsteaks displayed at 30°F. as influenced by the type of wrapping film being used. Film numbers correspond to those presented in table 6, page 9.

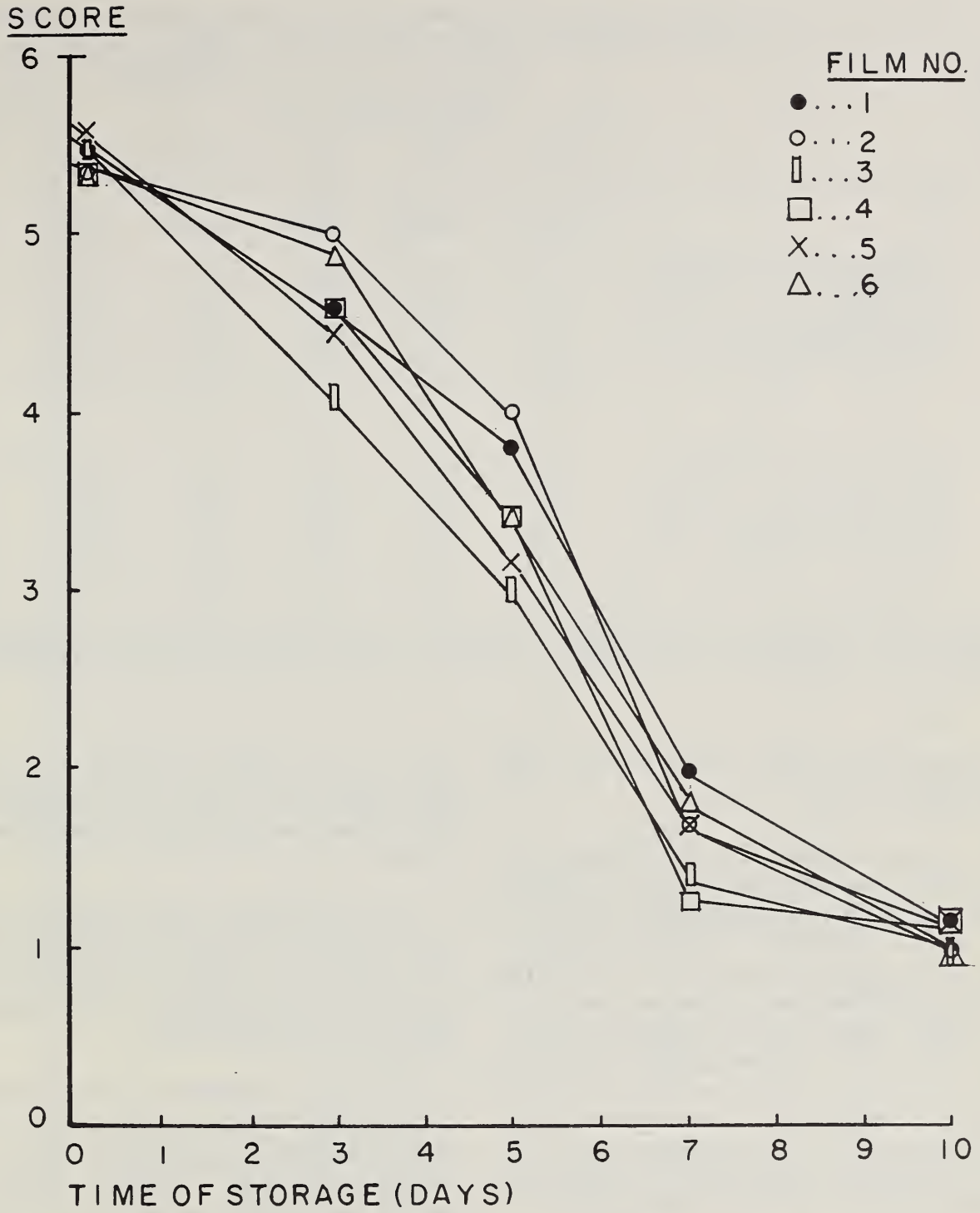

Figure 2.--Color desirability of beefsteaks displayed at 38° F., as influenced by the type of wrapping film being used. Film numbers correspond to those presented in table 6, page 9.

WEIGHT LOSS

The weight of the beefsteaks and the packaging materials ranged from 280 to 290 grams, with the initial tare weight averaging 18.4 grams. A comparison of the weight loss percentages for the various beefsteaks showed that those packaged in the standard red meat cellophane film averaged the greatest weight loss percentages over the 10-day display period (table 7). The lowest weight loss percentages were for the beefsteaks wrapped in

TABLE 7.--Weight loss as percentages of beefsteaks, with packaging materials included, packaged in 6 wrapping films by display temperature and display periods, Missouri, 1966-67

Temperature and Film No.	Film	Weight loss of beefsteaks in display case-- With light: For 3 days	For 5 days	For 7 days	For 10 days	Average[1]	Without light for 10 days
		Percent	Percent	Percent	Percent	Percent	Percent
30° F.:							
1	Standard red meat cellophane.....	1.87	2.15	3.65	5.40	3.27A	3.38
2	Polyethylene-coated cellophane...	0.55	0.57	0.84	1.10	.77 D	.65
3	Rubber base.....	0.40	1.07	1.37	1.39	1.06 C	1.45
4	Polyvinyl chloride.....	0.89	1.54	1.95	2.53	1.73 B	2.08
5	Polyolefin # 1 (stretch).....	0.14	0.46	0.54	0.90	0.51 D	1.09
6	Polyolefin # 2 (shrink).....	0.27	0.87	0.70	0.78	0.66 D	.92
	Average[1].....	0.69D	1.11C	1.51B	2.01A	--	1.60
38° F.:							
1	Standard red meat cellophane.....	2.28	2.40	4.23	5.94	3.71A	4.59
2	Polyethylene-coated cellophane...	0.74	1.05	1.32	1.66	1.17 D	1.67
3	Rubber base.....	0.78	1.32	1.56	2.82	1.62 C	1.69
4	Polyvinyl chloride.....	1.05	1.88	2.78	3.01	2.18 B	2.48
5	Polyolefin # 1 (stretch).....	0.35	0.49	0.82	1.40	0.77 D	1.19
6	Polyolefin # 2 (shrink).....	0.42	0.57	0.74	0.84	0.64 D	1.43
	Average[1].....	0.92C	1.28C	1.91B	2.61A	--	2.18

[1] Averages having the same letter within a row or a column are not significantly different. Tests Were administered at the 0.05 level of significance. No comparison was made between averages, which are identified by capital letters, and values within the table.

the polyethylene-coated cellophane and the two polyolefin films.

The average difference in weight loss between steaks wrapped in polyolefin #2 (shrink) and those wrapped in standard red meat cellophane was considerable. At 30° F., average weight loss of steak packaged in the standard red meat cellophane was 3.27 percent, whereas the average losses for the other five films ranged from 0.66 percent to 1.73 percent. Similar differences were found at 38° when the average weight loss of steak packaged in the standard red meat cellophane was 3.71 percent, whereas average losses for the other five films ranged from 0.64 to 2.18 percent.

Figures 3 and 4 illustrate graphically the weight loss for the six films at 30°F. and 38°, respectively. Figure 5 shows the same trend for all films combined.

Weighing the beefsteaks without the packaging materials produced the same trends as those shown in table 7. Again the steaks wrapped in the standard red meat cellophane packages lost the greatest percentage of weight, and those wrapped in the two polyolefin films lost the least (table 8). However, the percentage differences were not as great as those found when the packaging materials were included.

Comparing tables 7 and 8 indicates that with the exception of standard red meat cellophane, the greatest percentage of weight loss by the beefsteaks was absorbed by the materials in which they were packaged.

Overall, the standard red meat cellophane package absorbed the smallest percentage of weight lost by the beefsteaks (table 9). The polyethylene-coated cellophane package absorbed the greatest percentage of weight, an average of 2.92 percent at 30° F. and 2.61 percent at 38°. No determination was made of which material absorbed the weight--film or tray. Although it was assumed that the trays absorbed the same amount of moisture, it is possible that the packaging film influenced the absorption rate of the trays.

Most of the beefsteak packages displayed at 38° F. averaged a greater percentage of weight loss than those displayed at 30° (table 7). The steaks packaged in the two polyolefin films

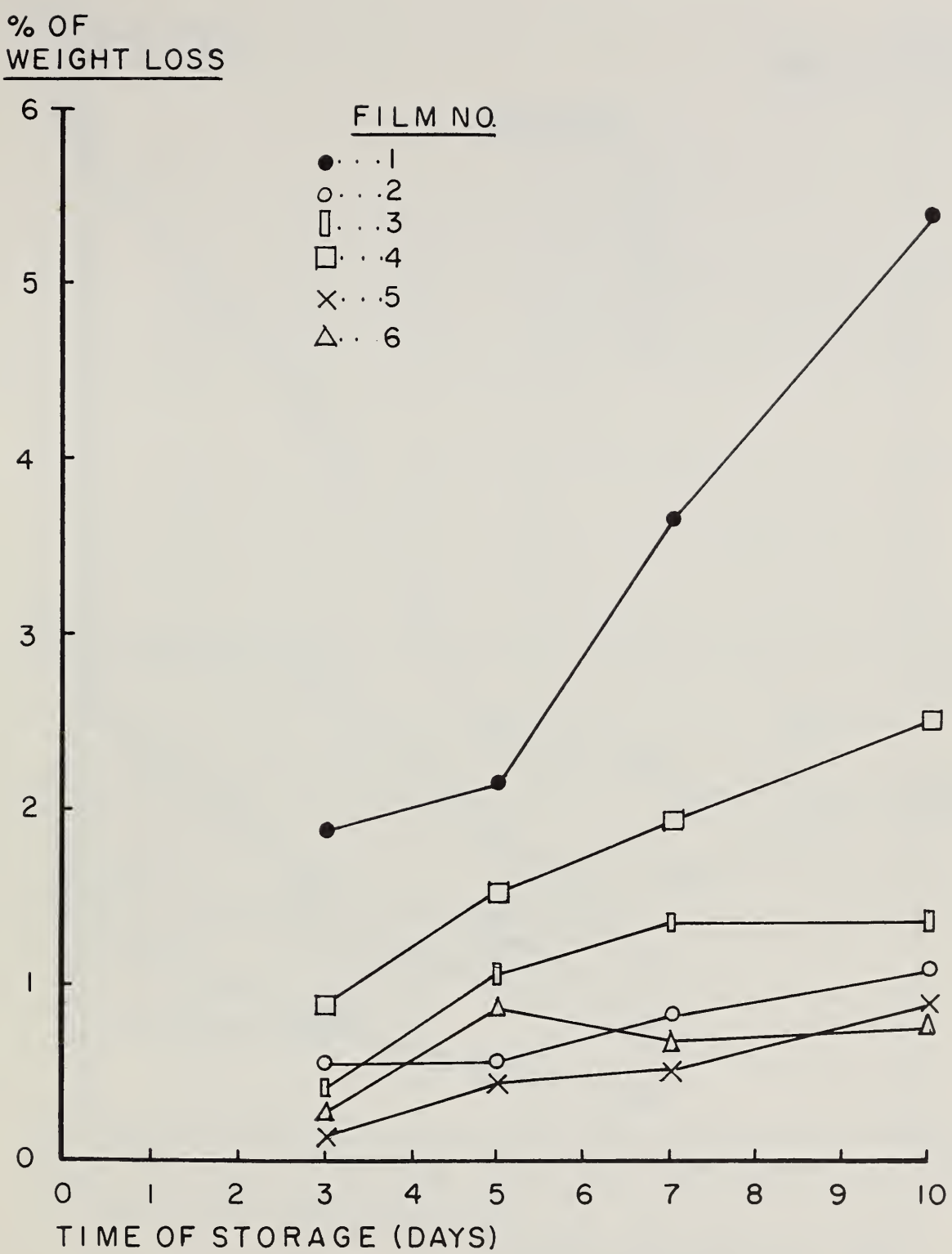

Figure 3.--Weight loss of beefsteak packages displayed at 30°F., as influenced by the type of wrapping film being used. Film numbers correspond to those presented in table 6, page 9.

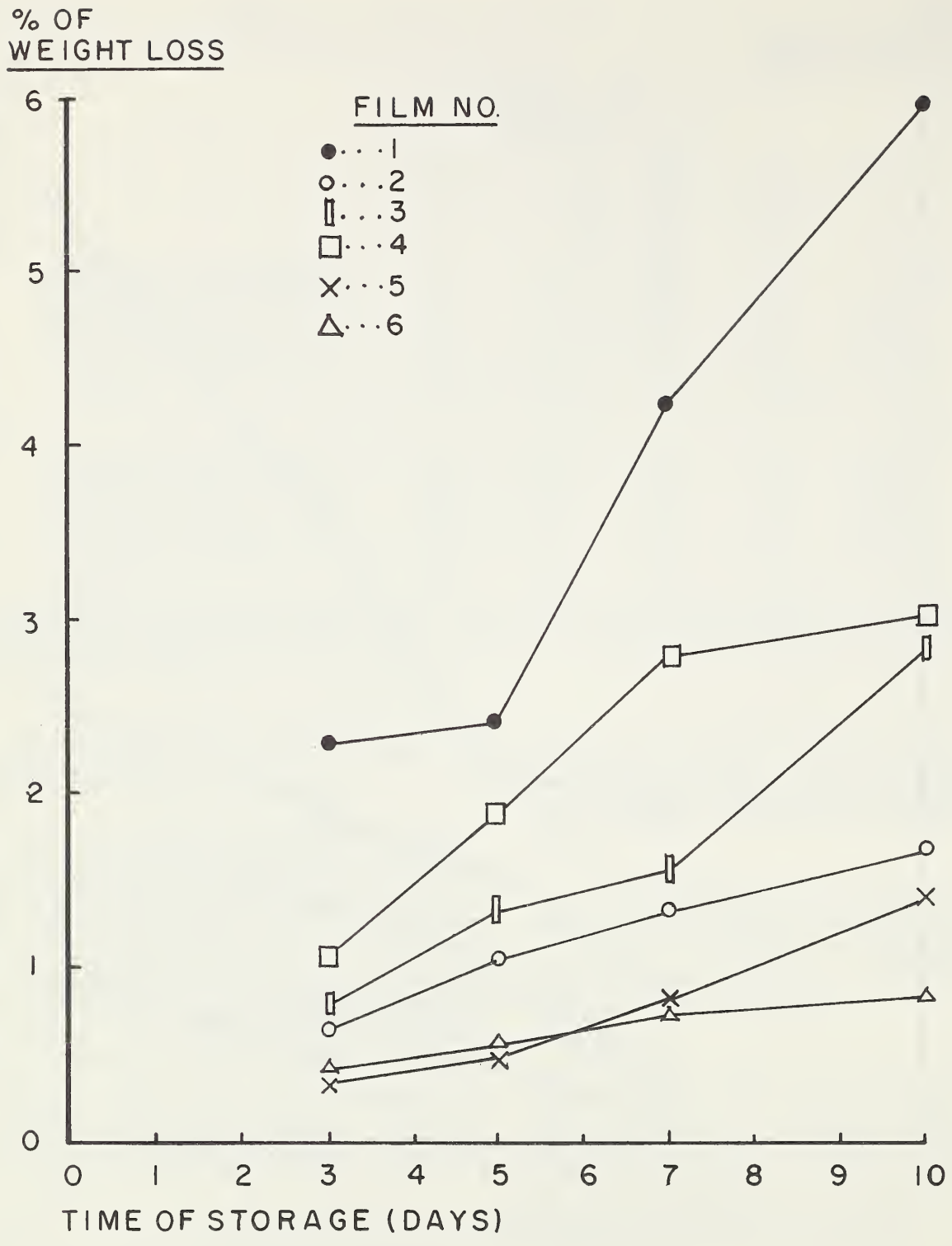

Figure 4.--Weight loss of beefsteaks displayed at 38° F., as influenced by the type of wrapping film being used. Film numbers correspond to those presented in table 6, page 9.

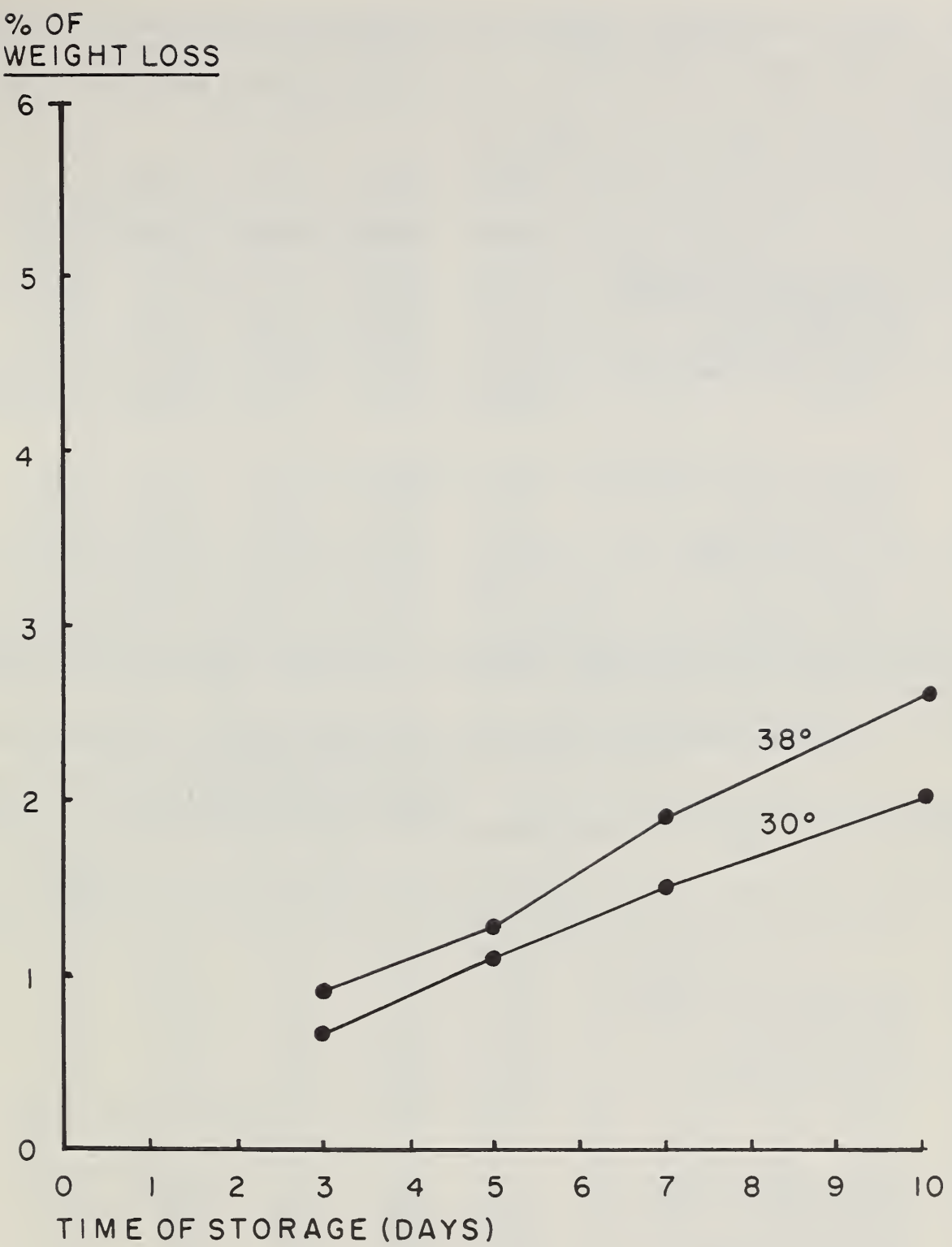

Figure 5.--Comparison of average weight loss of beefsteaks packaged in the six films tested and displayed at 30° and 38° F.

TABLE 8.--Weight loss as percentages of beefsteaks, without packaging materials included, packaged in 6 wrapping films by display temperature and display periods, Missouri, 1966-67

Temperature and Film No.	Film	Weight loss of beefsteaks in display case-- With light: For 3 days	For 5 days	For 7 days	For 10 days	Average[1]	Without light for 10 days
		Percent	Percent	Percent	Percent	Percent	Percent
30° F.:							
1	Standard red meat cellophane.....	3.76	4.19	5.41	6.65	5.00A	6.50
2	Polyethylene-coated cellophane...	3.51	3.67	3.29	4.25	3.68 BC	3.48
3	Rubber base.....	3.22	2.89	3.68	4.79	3.65 BC	3.50
4	Polyvinyl chloride.....	3.11	3.37	4.26	4.88	3.91 B	4.04
5	Polyolefin #1 (stretch).....	2.96	2.91	3.29	3.67	3.21 C	3.76
6	Polyolefin #2 (shrink).....	2.65	2.97	3.49	3.74	3.21 C	3.66
	Average[1].....	3.20C	3.33C	3.90B	4.66A	--	4.16
38° F.:							
1	Standard red meat cellophane.....	4.22	4.55	6.49	6.73	5.50A	6.10
2	Polyethylene-coated cellophane...	2.94	3.41	3.92	4.85	3.78 C	3.94
3	Rubber base.....	3.11	3.68	3.53	4.28	3.65 CD	3.64
4	Polyvinyl chloride.....	3.14	3.55	4.04	5.66	4.10 B	5.37
5	Polyolefin #1 (stretch).....	2.68	3.02	3.23	3.69	3.16 D	3.47
6	Polyolefin #2 (shrink).....	2.53	2.76	3.07	4.35	3.18 D	3.24
	Average[1].....	3.10C	3.50C	4.05B	4.93A	--	4.29

[1] Averages having the same letter or letters within a row or a column are not significantly different. Tests were administered at the 0.05 level of significance. No comparison was made between averages which are identified by capital letters, and values within the table.

TABLE 9.--Percentage of beefsteak weight loss absorbed by the packaging materials, 6 wrapping films by display temperature and display period, Missouri, 1966-67

Temperature and Film No.	Film	Weight loss of beefsteaks absorbed by packaging material in display case-- With light: 3 days	5 days	7 days	10 days	Average difference	Without light for 10 days
		Percent	Percent	Percent	Percent	Percent	Percent
30° F.:							
1	Standard red meat cellophane.....	1.89	2.04	1.76	1.25	1.74	3.12
2	Polyethylene-coated cellophane....	2.96	3.10	2.45	3.15	2.92	2.83
3	Rubber base.....	2.82	1.82	2.31	3.40	2.59	2.05
4	Polyvinyl chloride.....	2.22	1.83	2.31	2.35	2.18	1.96
5	Polyolefin #1 (stretch).....	2.82	2.45	2.75	2.77	2.70	2.67
6	Polyolefin #2 (shrink).....	2.38	2.10	2.79	2.96	2.56	2.74
	Average.....	2.52	2.22	2.40	2.65	--	2.56
38° F.:							
1	Standard red meat cellophane.....	1.94	2.15	2.26	0.79	1.79	1.51
2	Polyethylene-coated cellophane....	2.30	2.36	2.60	3.19	2.61	2.27
3	Rubber base.....	2.33	2.36	1.97	1.46	2.03	1.95
4	Polyvinyl chloride.....	2.09	1.67	1.26	2.65	1.92	2.89
5	Polyolefin #1 (stretch).....	2.33	2.53	2.41	2.29	2.39	2.28
6	Polyolefin #2 (shrink).....	2.11	2.19	2.33	3.51	2.54	1.81
	Average.....	2.18	2.21	2.14	2.32	--	2.12

showed the least difference between the two temperatures. However, when the meat was weighed without the packaging materials, these differences in weight loss due to temperature tended to disappear except in the case of standard red meat cellophane (table 8).

Generally, more of the weight lost by the beefsteaks was absorbed by the packaging materials at 30° F. than at 38° (table 9). This may indicate that many of the films studied tend to be more permeable at higher display temperatures and allow more of the weight

loss into the air rather than retaining it in the package. The standard red meat cellophane film package was the only exception with an average 0.05 percent greater absorption at 38°.

There was a significant interaction between the length of the display period and the amount of weight loss. The overall trend showed that the weight loss percentages of all steaks increased as the display period increased. Results for a few display periods were inconsistent with the overall results, but no conflicting pattern was found.

Generally, the beefsteaks lost less weight when displayed for 10 days without light than those displayed for 10 days with light. However, most packaging materials tended to absorb more of the weight loss from the meat when displayed with light than when displayed without light. The standard red meat cellophane was the only film that, at both temperatures, absorbed a greater amount of the weight loss when displayed without light (table 9). The rubber base and polyvinyl chloride film also absorbed a greater amount of the weight loss when displayed without light, but only at 38° F.

BACTERIA COUNTS

Bacteria counts declined between the 1st and 3d days in the display case set to give a meat surface temperature of 30° F. (table 10). This decline was probably due to temperature shock because the bacteria began to multiply after the 3d day. At the 38° display temperature, bacteria counts declined between the 1st and 3d days in only those steaks packaged in the standard red meat cellophane. After the 3d day, however, bacteria counts of most steaks increased as the time in the display case increased. This trend existed at both display temperatures and throughout the various display periods. The only exception was the standard red meat cellophane after the 3-day display period at 30°. The beefsteaks wrapped in the standard red meat cellophane generally had lower bacteria counts than those wrapped in the other five films (table 10).

Bacteria counts tended to be lower for beefsteaks displayed at 30° F. than those displayed

TABLE 10.--Logarithmic means for the bacteria counts of beefsteaks, packaged in 6 wrapping films by display temperature and display period, Missouri, 1966-67

Temperature and film no.	Film	Logarithmic means for bacteria counts of beefsteaks in display case[1]--						
		With light						Without light for 10 days
		For 0 days	For 3 days	For 5 days	For 7 days	For 10 days	Average	
30° F.:		Percent	Percent	Percent	Percent	Percent	Percent	Percent
1	Standard red meat cellophane.....	2.919	1.922	1.765	3.902	7.566	3.615	8.693
2	Polyethylene-coated cellophane.....	2.919	2.172	3.890	7.475	10.415	5.374	10.625
3	Rubber base.....	2.919	2.714	4.199	6.987	11.138	5.591	9.455
4	Polyvinyl chloride.....	2.919	1.626	5.772	8.959	11.702	6.196	8.183
5	Polyolefin #1 (stretch).....	2.919	1.804	3.648	5.329	11.571	5.054	9.877
6	Polyolefin #2 (shrink).....	2.919	2.264	4.537	8.227	11.031	5.976	10.092
	Average.....	2.919	2.084	2.381	6.813	10.571	--	9.488
38° F.:								
1	Standard red meat cellophane.....	2.919	2.431	7.002	10.491	14.835	7.536	13.291
2	Polyethylene-coated cellophane.....	2.919	3.385	7.576	14.182	15.556	8.724	13.888
3	Rubber base.....	2.919	3.036	10.221	12.954	17.901	9.406	15.267
4	Polyvinyl chloride.....	2.919	3.733	9.126	12.998	16.181	8.991	14.925
5	Polyolefin #1 (stretch).....	2.919	3.827	8.455	12.570	16.835	8.921	14.813
6	Polyolefin #2 (shrink).....	2.919	3.740	10.335	13.026	15.639	9.132	16.854
	Average.....	2.919	3.359	8.786	12.704	16.158	--	14.840

[1] Logarithms calculated to the base e.

at 38°. The higher display temperature caused greater bacteria growth, regardless of the wrapping film being used. The bacteria count increased noticeably in all the beefsteaks between the 3d and 5th days in the 38° case. The bacteria count also increased in the 30° case during the same time but the increases were not as noticeable.

Generally, the beefsteaks displayed for 10 days without light had lower bacteria counts than those displayed for 10 days with light. The only exceptions were the beefsteaks wrapped in the two cellophane films and displayed at 30° F. and the polyolefin #2 (shrink) film displayed at 38° that had slightly higher bacteria counts when displayed without light.

OBSERVATIONS

The sooner the meat can be sold after being placed in the display case the better for all concerned. The consumer gets a higher quality piece of meat with better color, less weight loss and lower bacteria count, and the retailer has fewer counter pulls and rewrap problems.

Under present conditions most retailers have sold all retail cuts by the 3d day or removed them from the display. All cuts in these tests were still saleable after 3 days. Additional shelf life, however, would reduce the need for counter pulls on slow-moving cuts. Additional shelf life can also make possible advance packaging of cuts. Even more important may be the effect on the consumer after she buys the cut. If a cut has been handled properly and will have good color for several more days, then the meat will appear fresher to the housewife when she gets it home.

APPENDIX

TABLE 11.--Subjective color description scores of beefsteaks packaged in 6 wrapping films by display temperature and display periods, Missouri, 1966-67[1]

Temperature and Film No.	Film	Color description scores of beefsteaks in display case[2]						
		With light						Without light for 10 days
		For 0 days	For 3 days	For 5 days	For 7 days	For 10 days	Average	
		Percent	Percent	Percent	Percent	Percent	Percent	Percent
30° F.:								
1	Standard red meat cellophane.....	4.34 b	4.00 b	3.45 b	3.36a	2.66a	2.56	3.58
2	Polyethylene-coated cellophane.....	4.64ab	4.59ab	4.48a	3.94a	2.84a	4.10	3.81
3	Rubber base.....	4.90a	4.50ab	4.10ab	4.06a	2.79a	4.07	3.50
4	Polyvinyl chloride.....	4.94a	4.28ab	4.10ab	3.61a	2.69a	3.92	3.30
5	Polyolefin # 1 (stretch).....	5.13a	4.41ab	4.31a	3.66a	2.75a	4.05	3.68
6	Polyolefin # 2 (shrink).....	5.00a	4.75a	4.23a	3.73a	2.75a	4.09	3.53
	Average.....	4.83	4.42	4.11	3.73	2.75	--	3.57
38° F.:								
1	Standard red meat cellophane.....	4.80a	3.71ab	3.34a	2.21a	1.56a	3.12	2.18
2	Polythylene-coated cellophane.....	4.65a	4.24a	3.63a	1.83a	1.45a	3.16	1.68
3	Rubber base.....	4.84a	3.31b	2.76a	1.68a	1.33a	2.78	1.43
4	Polyvinyl chloride.....	4.93a	4.01a	3.03a	1.61a	1.46a	3.01	1.59
5	Polyolefin # 1 (stretch).....	5.13a	3.85ab	3.04a	1.90a	1.45a	3.07	1.45
6	Polyolefin # 2 (shrink).....	4.68a	3.95a	3.04a	2.06a	1.35a	3.02	1.46
	Average.....	4.84	3.85	3.14	1.88	1.43	--	1.63

[1] Hedonic scale: 6 = bright; 1 = greenish.

[2] Film values having the same letters within a column are not significantly different. Tests were administered at the 0.05 level of significance.

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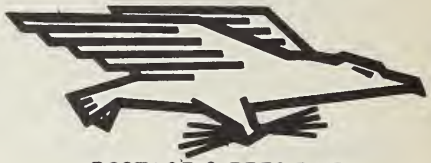

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